DePIN Tokenomics Part 1: Token Distribution Models, Incentive Mechanisms, Token Trends, and More.

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Key Insights

- The average token incentive issuance rate is more than **twice as high** for protocols running their own proprietary Layer-1s vs. those using general-purpose base layers.

- All DePIN incentive mechanisms require some sort of "skin-in-the-game": Digital Resource Networks (DRNs) primarily use a **Stake for Access** token incentive model, while Physical Resource Networks (PRNs) primarily use a **Node-Purchase** model.

- **Burn-and-Mint (BME)** and **Node-Purchase** models have become more common over time, driven by an increase in PRN launches**.** For example, the share of DePINs using BME more than doubled from pre-2022 launches (11%) to post-2022 launches (25%).

- DePINs mainly use centralized gateway companies or foundations to generate revenue with plans to **decentralize the demand side over time.**

Research Contents

Primer

Decentralized Physical Infrastructure Networks (DePINs) typically distribute token incentives to their node operators in return for supplying network services. Messari classifies DePINs into two main categories based on the type of underlying resource they procure:

- **Digital Resource Networks (DRNs)**, e.g., storage (e.g., Arweave, Filecoin), video streaming (e.g., Livepeer).
- **Physical Resource Networks (PRNs)**, e.g., 5G wireless (e.g., Helium, XNET), street maps (e.g., Hivemapper).
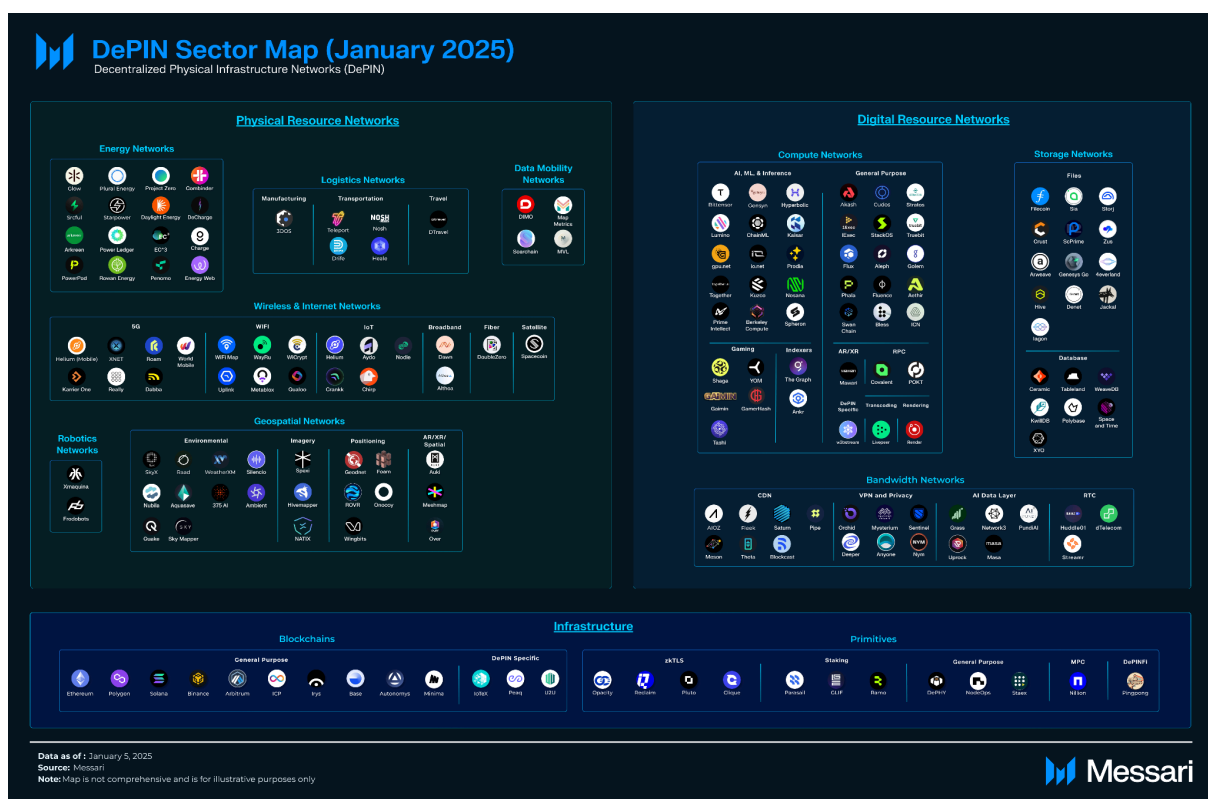
Source: Messari DePIN Sector Map

For an in-depth overview of the DePIN sector, please refer to Messari's State of DePIN 2024 report.

Why do DePINs distribute token incentives to their node operators? At launch, many DePINs face the classic chicken-and-egg problem: low user demand arises from an inadequate supply of services. To address this, most incentive mechanisms have historically prioritized bootstrapping the supply side.

Previous research has shown that many DePINs face challenges in designing effective token incentive structures for their node operators.

Below, we summarize our novel findings from analyzing the token incentives distributed by over 100 DePINs:

- **Finding 1**: The average token incentive issuance is more than twice as high for protocols running their proprietary Layer-1s vs. those using general-purpose base layers.

- **Finding 2**: Primary token incentive models differ for digital resource networks – DRNs (stake-for-access model) vs. physical resource networks – PRNs (node-purchase model).

- **Finding 3**: As more physical resource networks (PRNs) launch, token incentive mechanisms such as burn-and-mint equilibrium and node-purchase models have become more prevalent.

Inclusion Criteria

Precisely [defining](#) and [classifying](#) DePINs is an endeavor, as [debates](#) are ongoing. We took an inclusive approach when analyzing token incentive distributions in DePINs.

We sampled the [top 100 DePINs](#) by market capitalization, valued at approximately $38 billion as of the end of 2024. Additionally, we included DePINs likely to launch tokens in and beyond 2025 with known incentive distribution mechanics (e.g., Chirp, Starpower, Impossible Cloud).

However, our analysis does not include DePINs that do not distribute token incentives, such as Storj, iExec, and Spexi. Using the above inclusion criteria, our analysis focused on 90 DePINs.

Incentive Mechanisms in DePIN

Incentivizing node operators in DePINs usually means issuing new tokens and distributing them as incentives. There are three main mechanisms for distributing token incentives:

1) **Fixed issuance**: the distribution of token incentives depends on time (or some variation of time), such as the number of blocks (e.g. Arweave, Helium).

2) **KPI-driven issuance**: the distribution of token incentives depends on KPIs such as the number of tokens staked (e.g., Livepeer, Akash).

3) **A combination of fixed and KPI-driven issuance**: e.g., the distribution of Filecoin token incentives depends on time (fixed issuance) and capacity growth (KPI-driven issuance).
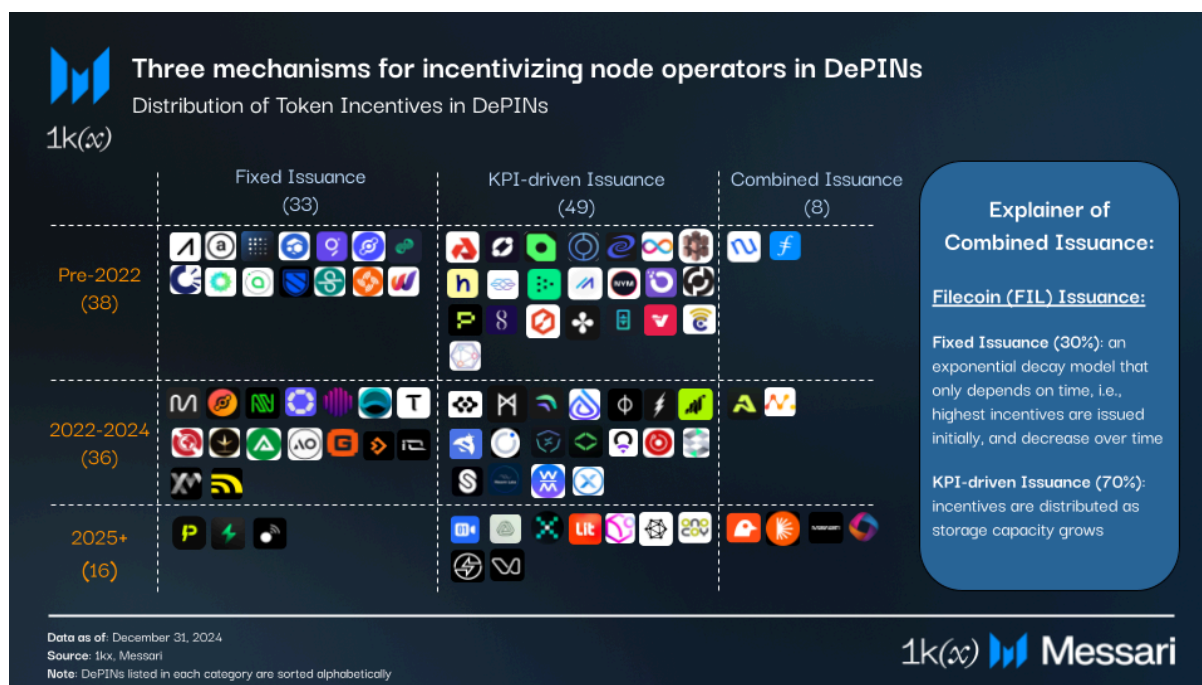
Our analysis found that 33 DePINs use fixed issuance, while 49 use KPI-driven issuance. Notably, eight DePINs (Nucypher – now Threshold, Filecoin, Netmind, Aethir, Chirp, Daylight, Qualoo, and Mawari) rely on a combination of fixed and KPI-driven issuance. The underlying data sources are listed in the ⊞ DePIN reward issuance . If you know of a DePIN missing from the above classification, please complete this form to be included in future research.

Finding 1: Significantly higher token incentive issuance rates for DePINs running their proprietary Layer-1

Pre-2022, 23/38 (60%) of the DePINs launched on their own, proprietary Layer-1s. However, only 11/52 (21%) of the DePINs launched in 2022 and onwards built their own proprietary Layer-1. Instead, most DePINs launched post-2022 used emerging base layers such as Solana, IoTeX, Peaq, Arbitrum, Base, Polygon, and others as their underlying infrastructure.

Furthermore, four DePINs launched pre-2022 transitioned to new infrastructure: Helium, Power Ledger, and Render migrated to Solana, while Orchid moved to its own Layer-2 appchain.
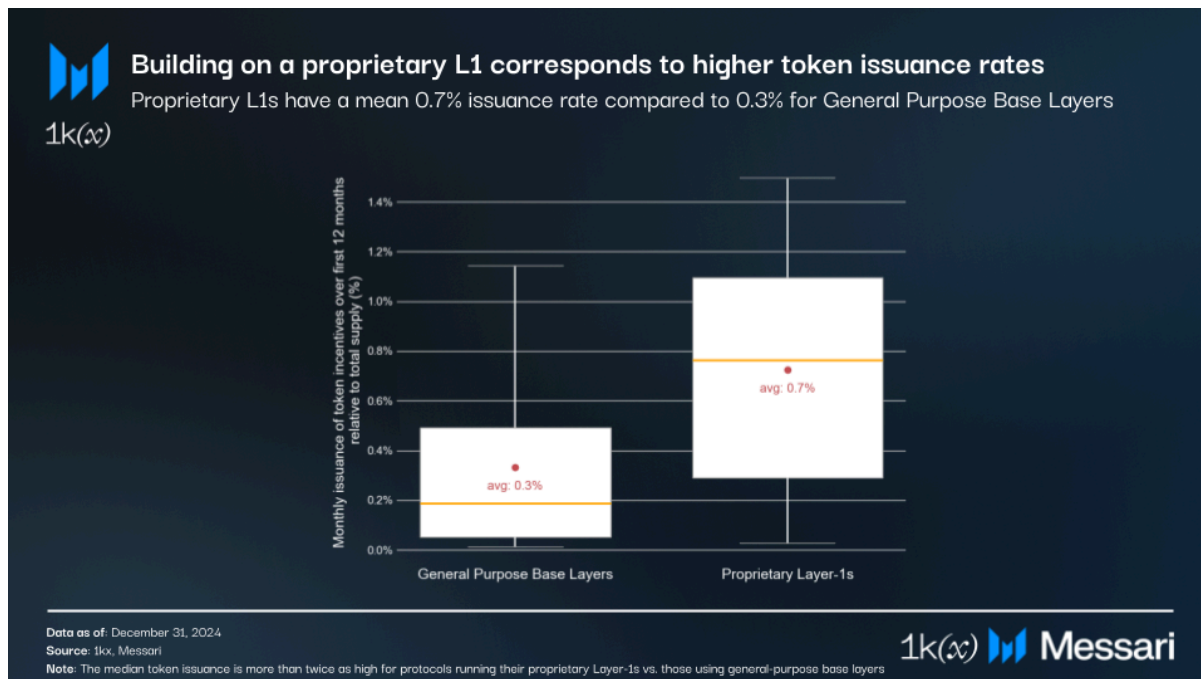
Leveraging general purpose base layers corresponds to a lower token incentive issuance rate, i.e., 0.3% monthly average (median 0.2%). Conversely, DePINs with proprietary Layer-1s tend to have a higher token incentive issuance rate, i.e., a 0.7% monthly average (median 0.75%). Therefore, **the median token incentive issuance rate is over three times as high for protocols running their proprietary Layer-1s versus those using general-purpose base layers**. While the above figures are for 12 months, the trend holds for all periods (i.e., 3, 6, 12, or 24 months). Given the high cost of operating base layers, it's not surprising that the overall incentive emissions are higher when running proprietary base layers.

However, it is worth highlighting that lower network operation costs (e.g., by decreasing the settlement costs by changing the underlying blockchain) do not imply lower token issuance rates. For instance, while DePINs like The Graph and Livepeer migrated from Ethereum to Arbitrum[1], their respective token issuance mechanisms remained independent of underlying infrastructure choice.

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[1] As shown by our research on cost estimation, Livepeer reduced their settlement-related cost by >90% migrating from Ethereum to Livepeer.

Finding 2: All incentive mechanisms require 'skin-in-the-game'. These differ for DRNs (stake-for-access) vs. PRNs (node-purchase)

Of the 90 DePINs analyzed, 66 (77%) use a staking mechanism. These DePINs typically follow the Stake-for-Access model. Participants in Stake-for-Access DePINs are required to stake a resource on the network to be eligible to perform services in exchange for token rewards.
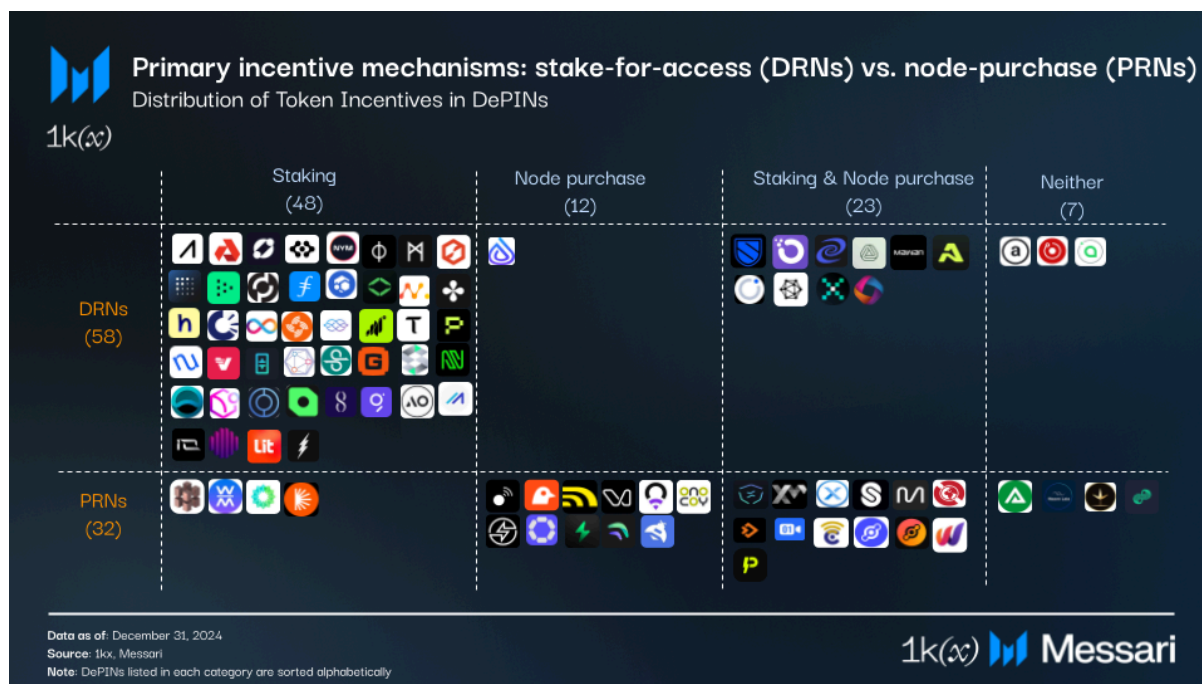
When comparing digital resource networks (DRNs) to physical resource networks (PRNs), we found that 44/58 (76%) of DRNs only use staking mechanisms. In comparison, 4/32 (13%) of PRNs (Foam, Wifimap, Power Ledger, Daylight) only use staking mechanisms (Note: no PRN uses the stake-for-access mechanism specifically).

This contrast can be explained by most PRNs requiring node operators to purchase dedicated hardware (e.g., hotspots, nodes). Using 'node purchases' to access the network as a supply participant in the network was implemented by 24/32 (75%) of the PRNs analyzed.

Requiring 'node purchases' establishes a similar incentive alignment to staking, i.e., contributors have skin in the game:

- **When staking**: the DePIN contributors have a vested interest that the protocol does well for their locked investment to do well.

- **When running dedicated nodes:** the DePIN contributors have a vested interest in the protocol's success since the node investment typically has little use outside the protocol.

As a result, PRNs do not typically have a critical need for token-based staking mechanisms. Notably, 23/90 (26%) of DePINs both have a staking model and require 'node purchases.' Such examples of staking with 'node purchases' include:

- DRNs: VPN-/privacy protocols like Orchid or Deeper.

- PRNs: miner deployment curation like ['hex-boosting'](#) by GEODNET and Helium Mobile; ensuring non-malicious behavior by hardware manufacturers, as implemented by Helium and Dimo.

Conversely, DePINs that neither use staking nor node purchases can be found among both as well. Typically they also have mechanisms that aim to achieve a similar alignment to staking or node-purchases:

- DRNs: e.g., Arweave, Sia, and Render. For instance, Arweave has a mechanism called [Adaptive Interacting Incentive Agents](#), a peer-based ranking system that aligns miners' performance with their ability to earn Arweave block rewards.

- PRNs: e.g., Akreen, Nodle, WeaverLabs, and Glow. For instance, Glow solar farms joining the protocol commit their 10-year revenue in exchange for access to the protocol and token rewards. Similarly, Weaver Labs requires specialized hardware to provide cellular coverage.

Finding 3: As more PRNs launch, burn-and-mint equilibrium, and node-purchase models have become more prevalent

An increasing number of DePINs leverage the [burn-and-mint equilibrium](#) model[2] ([BME](#)) to balance token incentives with service demand: While pre-2022, only 4/38 (11%) DePINs used burn-and-mint equilibrium (BME), post-2022, this share more than doubled to 13/52 (25%).

Nine of the 13 protocols launched post-2022 using BME are PRNs, while pre-2022 Helium was the only PRN using BME. The increase in BME adoption corresponds to an increase in PRNs in our dataset: pre-2022, there were 6/38 (16%) PRNs, while from 2022 and onwards, it was 26/52 (50%).

The increase in PRNs launching post-2022 may also explain the increase in node-purchase models. While pre-2022, only 6/38 (11%) of DePINs offered node purchases, the share of DePINs offering node purchases rose to 58% post-2022.

This trend also holds for burn mechanisms in general: 39 DePINs burn part of their incoming fees directly or via buy-back-and-burn (18), use the burn-and-mint equilibrium model (16), use burn of tokens related to the slashing of node operator stake (5), or use a combination of these (2). Pre-2022, 9/38 (24%) protocols had a burn mechanism. Post-2022, this proportion

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[2] Including adjusted versions like [burn-credit-mint](#) (e.g. by Auki) or [burn-mint-work](#) (e.g. by Inferix). Those and the original BME are a way to achieve fixed costs for their service whilst translating the monetized demand to token demand.

increased to 32/52 (62%). Also, existing DePINs added a burn mechanism; notable examples include:

- Filecoin introduced the burn mechanism inspired by Ethereum's EIP-1559 in 2022.

- Render switched to a burn-and-mint-equilibrium model in 2023.

- POKT Network introduced burning with the decentralization of their Gateways in 2023.

There's More: DePIN Token Trends

New forms of incentive designs: While distribution schedules of token incentives (be it fixed, KPI-based, or combined issuance) define the overall incentive budgets, DePINs introduced various innovations in distributing token incentives in 2024:

- **Curation via staking or NFT purchase**: A common question for DePINs is where and how to offer services. The Graph pioneered a curation mechanism based on bonding curves, while Foam used a stake-based approach. PRNs expanded on these ideas, notably in two ways:

    - **Stake-based curation (medallions)**: Medallions leverage network participants in allocating network incentives. E.g., in the [DAWN Network](#), anyone can stake a minimum number of tokens in a specific area to unlock rewards multipliers for users in that area. In exchange, stakers received a share of revenue in that area. As a result, local expertise and market-driven incentives can be leveraged to maximize network efficiency. This effectively drives market-making incentives to drive intra-ecosystem price discovery: e.g., in both DAWN and Daylight, the aggregate of prices of minted medallions is used to distribute rewards across multiple regions, rather than using external oracles (like, e.g., Helium which layers multiple layers to determine foot traffic or existing telco coverage by location).

    - **NFT-based curation**: Natix plans to enable curators to buy [iLand NFTs](#) for a revenue share of that particular land tile.

- **Node sales to early supporters**: Historically, DePINs had specific nodes that either provided the service (e.g., [WiFi routers](#)) or helped validate services provided by other network contributors (e.g., [Checker nodes](#))[3]. In 2024, nodes began to be sold pre-token launch. Buyers would, e.g., provide ETH and get the right to earn future incentives when running the nodes. Examples include [Aethir](#), [Impossible Cloud](#), and [GPU.net](#), which use a node-purchase model as an incentive alignment mechanism, as described in Finding 2.

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[3] Nodes must not be hardware in all cases, e.g. Aethir's checker nodes are a software client running specific software whilst the node-ownership (and hence right to earn rewards) is represented as NFT.

Onboarding 'early supporters' ensures stickiness, given the upfront capital commitment, i.e., "put your money where your mouth is." Even after the token launch, some DePINs used a node sale to tap into this group of 'believers,' e.g., Ator/Anyone did a pre-sale of their hardware via NFTs. The first node-as-a-service operators, as offered by DePIN Hub, continued the trend.

Upgrade to token designs: A large portion of the protocols with tokens launched before 2024 subsequently came out with significant adjustments to their token designs, e.g.:

- Helium built the sub-DAO model to expand HNT utility as a token for a network of networks, introducing additional tokens (IOT and MOBILE). Whilst the sub-DAOs are aimed for governance, Helium returned to a single token model in late 2024. Additional adjustments include hexboost, change of incentive allocations, fees, and more.
- Akash 2.0 introduced a community tax on staking rewards to foster service demand, added a burn mechanism, and overhauled fee structures.
- IOTEX 2.0 expanded their Layer-1 into a modular stack and a corresponding improvement of the token model, including burn and restaking of IOTX. This stack provides infrastructure to DePINs beyond blockchain operations. For instance, DePINs like enviroBLOQ, Network3, or GEODNET leverage the ioID tokenomics to incentivize physical device registration as part of the ioID universal identity system.
- DIMO token upgrade added credit tokens for service payments, adjusted fee structure, planned migration to Base.
- Bittensor: dynamic TAO (dTAO) transitions the network's reward allocation system from a voting system to a market-based one.
- Covalent: implementation of the updated whitepaper includes separation of data indexing roles, related (delegated) staking rewards, and migration to a new token.

Migrations and Mergers:
- Migrations or expansions to other blockchains, e.g.:
  - To Solana: Power Ledger, Helium, Render, XNET, GEODNET (expansion).
  - To Arbitrum: Livepeer, TheGraph.
  - To Appchain: Orchid (ETH L2), Phala (ETH L2, planned), Pokt (Cosmos).
  - To ZkSync: Nodle.
  - To Base: World Mobile Token (expansion), Dimo (planned).

- Mergers with other protocols:
  - Nucypher and Threshold into Threshold protocol
  - Fetch.ai, Ocean, Singularity.net into the Artificial Superintelligence Alliance (ASI). Cudos joined the merger later on as well

Tackling the demand side: Many DePINs source their demand in a primarily centralized fashion via a gateway foundation or company that manages pricing, sales and marketing needs as well as off-chain payments. Consequently, the focus of incentive design has been on the supply-side so far. In addition, incentivizing the demand side directly is not straightforward due to the gamification opportunity it creates (e.g. as Helium experienced in its early days). However, there are examples of approaches to incentivize the demand-side, e.g.:

- [Filecoin's Filecoin+](link) has appointed notaries that manage the allocation of additional rewards for verified and higher quality storage services targeting enterprise collaborations.
- [POKT Network](link) decentralized its gateways by:
  - Allowing individual gateway pricing and service-level agreements with users.
  - Paying a fixed price per relay to route requests through the POKT Network.

  This essentially made POKT gateways decentralized sales teams.
- [Akash](link) introduced a community pool tax taken as share of the staking rewards budget in order to fund various demand and ecosystem incentives. E.g., ongoing provider incentives target particular GPU-setups that are highly utilized, so tenants can always find GPU resources they need at competitive prices.
- [Render](link) and [Inferix](link) have programs to reward artists when using their platforms for rendering their work.

Additionally, many newer DePINs already bring substantial demand e.g. from Web2 operations (e.g. ICN, Spexi,...).

Conclusion

Our findings suggest DePINs that operate on general purpose blockchains reduce token incentive issuance rates significantly (>50%) vs. those that use their proprietary L1.

All incentive mechanisms require some sort of "skin-in-the-game". Depending on the underlying service offered by DePINs, these mechanisms differ for DRNs (stake-for-access model) vs. PRNs (node-purchase model).

As more PRNs launch, token incentive mechanisms such as burn-and-mint equilibrium and node-purchase models have become more prevalent.

Why should DePIN operators and investors care about these findings?

For established DePINs, we suggest the following approach:

- Continuously monitor, expand, and refine incentive structures to meet evolving user demand.

- Adjust infrastructure setups (e.g., changing the settlement layer) for increased efficiency.

- Explore expansion opportunities by adopting strategies like Helium's "networks of networks" model or IoTeX's re-staking, while avoiding token model complexity, as seen in Helium's return to a single-token system.

For new DePINs, we suggest leveraging insights from established DePINs by:

- Incorporating successful approaches (e.g., staking and node purchases)

- Learning from approaches that did not work (e.g., Pollen Network, Hivemapper)

This applies to token design, specifically the overall issuance of token incentives and their allocation across different contributing functions. For bootstrapping demand, a viable approach

is to initially centralize demand through a gateway or foundation and then gradually transition to decentralization.

DePIN investors can benefit by actively participating in the network, such as operating nodes or delegating tokens to earn extra incentives. DePINs launched before 2024 achieved success through significant experimentation. This iterative process helped most DePINs refine the balance between incentive distribution and service demand.

DePINs launched in or after 2024 have the advantage of building on the lessons learned from earlier experimentation. However, further progress is needed to optimize demand-side incentives, establish effective monetization strategies, and achieve long-term profitability. Established DePINs can leverage the strong communities they have cultivated over time to support these efforts.

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